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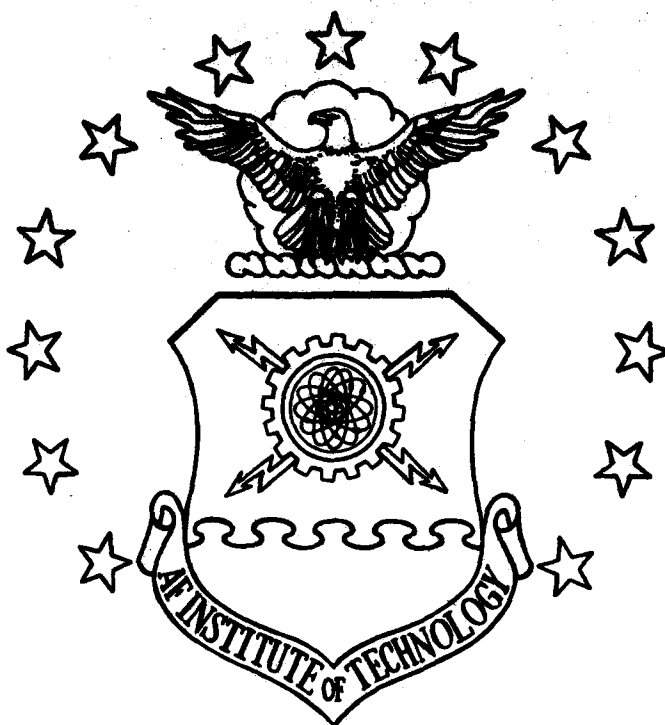
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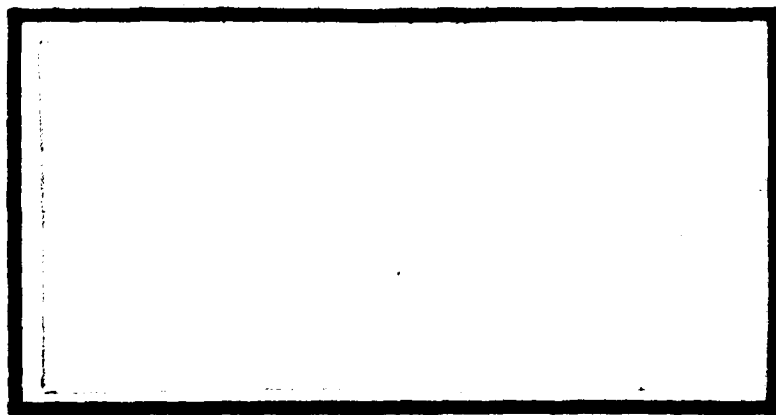
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FULL SCALE ENGINEERING DEVELOPMENT
STATEMENTS OF WORK

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It is commonly believed by many members of the acquisition community that Full Scale Engineering Development (FSED) Statements of Work (SOWs) often fail to successfully communicate the Government's requirements to the contractor; and that this communication failure causes some of the problems in DOD Systems Acquisition efforts. A significant body of research and study supports these beliefs and demonstrates interest in improving FSED SOW communication of requirements. This research was designed to identify the factors that contribute to successful FSED SOW communication and to determine if SOW experts agree that some factors identified contribute more to successful SOW communication than others. Information obtained in personal interviews with SOW experts resulted in a list of 25 factors that were synthesized into 7 subject categories: requirements, consistency, internal document organization, contract cross-referencing, language, contractor participation, and Government personnel team effort. There was agreement among SOW experts as to the importance of the seven subject categories of the factors. The study recommends that all seven categories be widely disseminated to the acquisition community; and that managers actively promote consideration and application of them to FSED SOW writing efforts. Research is recommended into quantification and measurement of individual factors and communication success.

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SUCCESSFUL COMMUNICATION IN
FULL SCALE ENGINEERING DEVELOPMENT
STATEMENTS OF WORK

A Thesis

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Logistics Management

By

James C. David, BS
GS-12

Joseph S. Price, BS
First Lieutenant, USAF

June 1980

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This thesis, written by

Mr. James C. David

and

First Lieutenant Joseph S. Price

has been accepted by the undersigned on behalf of the
faculty of the School of Systems and Logistics in partial
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CHAPTER I

INTRODUCTION

In response to changing military threats and mission requirements, the Department of Defense (DOD) purchases a wide variety of complex systems from industry. To assure that industry develops and produces systems that are adequate to meet defense needs, DOD contracts with industry often include a Statement of Work (SOW).

The purpose of the SOW is to communicate to the contractor the tasks and requirements that the Government wishes the contractor to perform (16). The SOW serves as a definitive reference for what the Government and the contractor agree that the contractor is to do and the Government is to pay for. A SOW is thus distinguished from a specification: "The System Specification must be a complete set of minimum performance requirements. . .[20]," of the developmental hardware, and software, e.g., mission, weight, size, speed, range, accuracy, etc. The specification describes how the system hardware and software being purchased must perform. The Statement of Work, in contrast, describes how and what the contractor must perform, generally:

(a) the generic nature of the tasks to satisfy specification requirements, i.e., design, tests, analyses, etc., . . . (b) identification of contractor obligations to the Government for formal reviews and day-to-day working relationships; and (c) identifications of necessary plans . . . which must be conducted by the contractor [20].

Some examples of the type of tasks or requirements expressed in the SOW are reliability and performance tests, quality assurance programs, management systems and data, cost and schedule reports, and maintainability programs.

Problem Statement

Many problems encountered in DOD system contract efforts are attributed, in part, to the failure of the contract Statement of Work to successfully communicate the Government's requirements to the contractor.

SOW communication is the activity of Government requirements being transmitted by a SOW and received by a contractor. Successful SOW communication is the event of SOW-transmitted Government requirements being received and interpreted by a contractor as the Government intended.

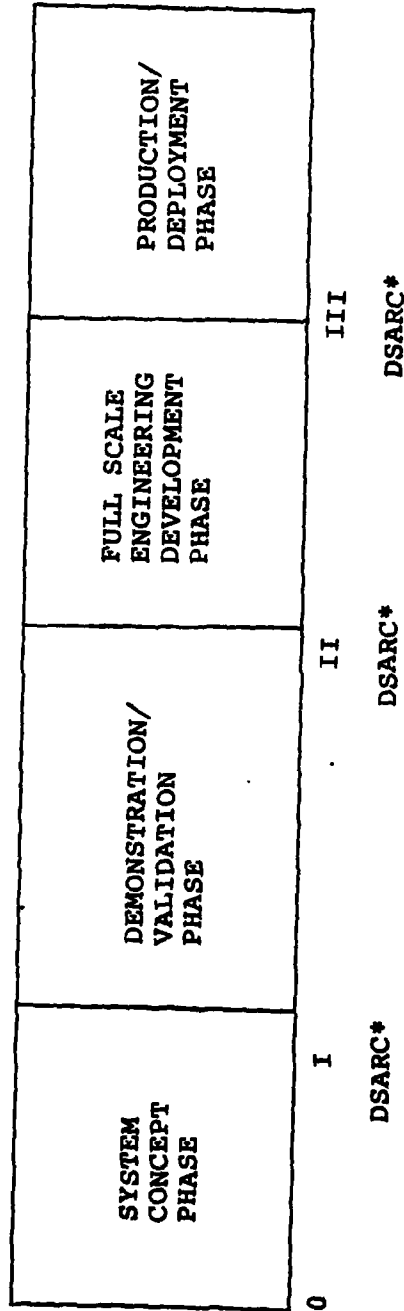
The process of DOD system acquisition would be improved by a knowledge of the factors that contribute to successful SOW communication and the relative importance of these factors.

Scope of Research

DOD systems are acquired through a cycle of logical phases that are prescribed by the DOD 5000 series of directives (Figure 1). Each phase has unique characteristics and requirements. The contract Statement of Work for each phase must be written with these characteristics and requirements in mind (2). As the system progresses through each phase, the requirements become more specific, technical freedom gives way to management constraint; uncertainty is reduced and the Government frequently exerts increasing control over the contractor's activities.

The Full Scale Engineering Development (FSED) phase is characterized by moderate uncertainty; "some unanticipated unknowns may be encountered, but the level of the knowns in the uncertainty continuum has increased [5:14]." J.R. Fox cites six prerequisites that mark the beginning of FSED:

1. Primarily engineering, rather than experimental, effort is required.
2. The mission and performance envelopes are defined.
3. The best perceived technical approaches have been selected.
4. A thorough trade-off analysis has been made.
5. Cost effectiveness for the proposed weapon system and competing systems within the Defense Department have been compared, and the proposal is considered feasible.
6. Cost and schedule estimates are credible and acceptable. [9:16].



* DEFENSE SYSTEM ACQUISITION REVIEW COUNCILS

FIGURE 1. THE SYSTEM ACQUISITION CYCLE [16;28]

There is a noticeable increase in the level of participation in system program management activities by many organizations outside the program/acquisition management office, e.g., the system user organization, logistics, training, safety, test, and engineering organizations. Their participation is essential to sound technical and management decisions, but the interaction of these various functional disciplines causes communication to be a very complex activity. This complexity of communication renders FSED the phase of the acquisition cycle where successful SOW communication is probably the most difficult to achieve. The imperatives of the functional disciplines often conflict with each other, making the Statement of Work most difficult to write at the time it is most important to successful completion of system development. FSED is the final determinant of successful new system production. A significant portion of defense research and development dollars are spent in FSED.

In light of the complexity of the FSED phase and the difficulty of obtaining successful communication through FSED SOWs, FSED was considered a fruitful starting point for research into successful SOW communication. The scope of this research was therefore limited to FSED SOWs.

CHAPTER II

BACKGROUND

The SOW in the FSED Phase Contract

Chapter I provided an introduction to the Statement of Work and the difficulty of writing a SOW during the FSED phase of system acquisition. A complete understanding of successful FSED SOW communication, however, requires an understanding of the SOW as an FSED contract document.

Like all system acquisition cycle phases, FSED is implemented by one or more contracts. Each contract is generated and managed in a standard sequence of steps (Figure 2): requirements generation, planning, offer and evaluation and contract management (16). The SOW is developed and written early in this process, during requirements generation (16), and provides a description of contractor tasks throughout the remaining steps.

The SOW provides a part of the baseline from which contract funds requirements are estimated. These estimates determine the dollar level of the purchase request which marks the beginning of the planning step.

During planning, the SOW remains the major description of what the Government expects of a potential contractor. Much of the planning takes place according to what is in the SOW.

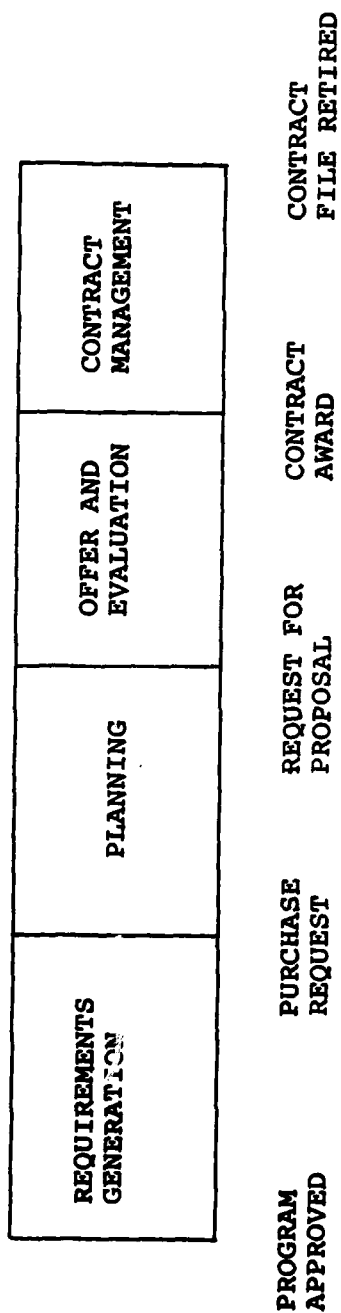


FIGURE 2. THE CONTRACTING PROCESS [16]

The SOW is an essential element of the Government solicitation of potential contractors, usually accomplished through the Request for Proposal (RFP). "The first attempt to translate precontract activity into a communication to industry [7:9]," the RFP functions to "obtain a legal and binding offer to perform from a prospective contractor [11:2,3]."

The issuance of the RFP marks the beginning of the offer and evaluation step of the contracting process, during which the Government selects its contractor. Offerors respond to the RFP with proposals describing the technical, management and cost conditions under which they are willing to perform the Government's requirements.

The SOW is the major description of requirements in the RFP for the potential contractor. The SOW must communicate the technical requirements of engineers and the management requirements of many specialists, while "permitting close estimation of the economic resources needed to fulfill these requirements [11:1]."

From what the SOW communicates to the offerors, the offerors estimate costs and develop proposals. It is therefore imperative that the SOW be well organized and communicate clearly (17;21;23).

After receipt of offers from industry, the Government evaluates the offers for the combination of technical, management, and cost considerations most advantageous to the Government. Generally, system acquisitions are of the complexity and dollar value that require the selected offer to be negotiated (16). During negotiation, the SOW that was included in the RFP may undergo many changes as Government and offeror arrive at a mutually acceptable combination of requirements and price. The original SOW remains the framework for the negotiated SOW (SOWs are amended but rarely rewritten); thus, the ability of the negotiated SOW to successfully communicate Government requirements is very dependent on the original SOW's ability to do so.

Following successful negotiations, the Government awards a contract to the offeror (now contractor). The contract, simply defined, is "an enforceable agreement entered into by two legally equivalent persons [12:3,4]." The negotiated SOW is an integral part of that contract. Therefore, the SOW must be "complete and legally enforceable [10:1]." The SOW should, however, convey only those requirements that are not accommodated in the other parts of the contract (23).

During the contract management step (generally the longest of the steps) contractor performance is compared with the SOW for sufficiency. The SOW here serves as a record of what the Government and contractor understand the requirements to be. When the requirements are completed, the SOW is often used as an acceptance document (11:3).

The SOW thus plays an extended and versatile role through the entire contracting process during FSED. The importance of the SOW is officially recognized in the primary controlling regulation of DOD contracting, the Defense Acquisition Regulation (DAR): "The preparation and use of a clear and complete Statement of Work is essential to sound contracting for Research and Development [27:4:3]." Herbert Howe, Chief of Contract Administration of the Air Force Plant Representative Office, General Electric Company, Evendale, Ohio, stated this in more succinct terms: "You can't put out a good contract if you start with a poor SOW [13:1]."

Research Justification

The importance of the research was revealed by a search of existing knowledge of the problem. It was shown that there is a common belief that SOWs often do not

achieve their main purpose, i.e., successful communication of requirements, that there is interest in solving the problem, and that there are potential benefits in a solution.

Problem Knowledge. The knowledge search has shown that few of the sources of existing knowledge dealt with SOW communication per se. They addressed SOW problems in a variety of terms: poor quality, length, redundancy, lack of uniform structure, content, lack of clarity, poor definition of requirements, misunderstandings, cost, schedule and performance problems, and claims against the Government. These terms all suggest an underlying problem: a failure of the Government and the contractor to successfully communicate.

The specific results of the knowledge search are discussed in the next two sections.

Problem Existence. Problems with SOW communication of requirements have been documented since the early 1970s.

Research by the Army Procurement Research Center in 1973 found "diversity of structure, and lack of brevity and clarity [29:iv]" of RFPs and the SOWs within them. A University of Maryland unpublished research report indicated frequent industry

dissatisfaction with the lack of clarity in the Government's expression of requirements in RFPs (15). The Aeronautical Systems Division (ASD) of AFSC has documented similar findings; a 1976 statement from the Directorate of Procurement and Production expressed concern over "continued decline in the quality of Statements of Work," citing redundance, vague language, and ambiguities as frequent problems that surfaced in contract reviews (23).

An ASD study of the status of RFPs, revealed that SOW requirements are frequently redundant to or in conflict with other RFP or contract requirements such as data items and special provisions (3). A 1977 ASD study of RFP improvement methods suggested elimination of SOW duplication of requirements expressed in the specification (22:4).

When interviewed by the researchers, several officials at ASD indicated that these problems continue to plague acquisition efforts (4,8,21).

The Air Force Acquisition Logistics Division maintains a Lessons Learned File that documents mistakes and oversights in Statements of Work (1).

The result of these efforts has not been remediation of problems nor improved communication. J.A. Boykin stated that the SOW "has evolved into a monster" that invites duplication and contradictions (3), lending the impression that previous SOW improvement efforts haven't

been successful. Howe stated: "Many attempts have been made to improve the quality of the SOW. In my opinion, they have not been very effective [13:1]."

Problem Interest. Interest in solving SOW communication problems is not new. Staff studies at the Space Systems Division indicate an interest in SOW quality as early as 1963 (10). The Army Materiel Command commissioned a study to improve work statement quality (26:1,5). In 1966, Air Force Systems Command (AFSC) was, for similar purposes, drafting a work statement writing guide (AFSCM 70-XX) during this period (26:63). The Space and Missile Systems Organization of AFSC established a Statement of Work review office prior to its 1979 reorganization.

Howe indicated continued interest in problems in the acquisition cycle. He suggested improvements in the mechanics of SOW writing, identified some of the behavioral aspects of requirements generation and explained the roles of the involved parties (10,11,12,13,14).

Continual cost, schedule and performance problems with Air Force acquisition prompted General Alton D. Slay, upon assuming the position of Commander, AFSC, in 1978, to issue Commander's Policy Letter Number 22 which, among other things, called for "clear delineation of the requirement [2]." That letter was subsequently rewritten as AFSC Regulation 550-22.

Research Benefits. This research focuses upon factors that contribute to successful SOW communication. A knowledge of such factors may enable acquisition personnel to better understand SOW communication and produce SOWs that contribute better to communication success. SOWs that communicate successfully may contribute to the reduction of cost, schedule, and performance problems, and the frequency and severity of claims against the Government. The knowledge of successful communication factors may also provide an origin for additional research.

Research Objectives

In order to obtain a knowledge of factors for successful FSED SOW communication, the researchers focused on two objectives:

1. To identify primary factors that contribute to successful FSED SOW communication of requirements.
2. To determine if SOW experts agree that some factors identified contribute more to successful communication than others.

These objectives were structured as a research question and a research hypothesis.

Research Question.

The first research objective was structured as an exploratory question: What are the factors that contribute to successful FSED SOW communication?

Research Hypothesis.

The second research objective was structured as a statistically testable research hypothesis: There is agreement as to the importance of the factors identified by the Research Question.

CHAPTER III

RESEARCH METHODOLOGY

The Statement of Work is an important instrument in contracting for major system Full Scale Engineering Development. It serves as a primary medium of communication of Government requirement to the contractor. Yet, it is recognized throughout the system acquisition community, from top policy makers to contract negotiators and administrators, that SOWs frequently fail to secure successful communication between Government and contractors. In concert with the research objectives of identifying factors that contribute to successful SOW communication, and determining if some factors are more important than others, this Chapter explains the methods employed to locate, secure, and analyze the data necessary to meet the objectives.

Data Source

"Probably only a very small portion of existing knowledge and experience is ever put into written form [24:55]." It was therefore decided to survey the knowledge and experience of personnel currently working with FSED

SOWs. Knowledge of and experience with FSED SOWs may be available in a variety of organizations and disciplines. This research, however, was directed toward the perspectives of contracts personnel. Although personnel of other disciplines usually write the SOW, contracts personnel must contend with the communications results of the SOW (14).

These contracts personnel were approached first to identify factors that contribute to successful FSED SOW communication, and second to address the order of importance of the collected factors.

Many people work in the contracts specialty but not all were capable of providing data meaningful to this research. It was necessary to restrict the survey to a meaningful level of expertise in FSED SOWs. This was accomplished by establishing the following minimum criteria for SOW experts.

1. Thirty or more months of total experience in systems acquisition. The researchers considered this a minimum time in which military or civilian contracts personnel could become familiar enough with FSED programs and SOWs to form reasonable, generalized opinions concerning these subjects.

2. Grade of O-2, GS-11 or above. These grades are above the entry grades of O-1 and GS-09 or GS-10 that typically are assigned to contracting and management positions. The higher grades are commensurate with the thirty months experience in systems acquisition required.

3. Current assignment in the disciplines of contracting, contract review, contract policy, or contract management.

4. Experience in more than one DOD program or work assignment. The researchers considered the breadth of experience necessary for experts to develop general opinions.

5. Past participation, twice or more, in the activities of writing FSED SOWs or writing, negotiating, or managing FSED contracts. Depth of experience in FSED SOW or contract activities was considered important to meaningful opinion formulation.

Research Universe

The SOW is used as a vehicle of communication in contracts for major systems throughout DOD. While these systems differ in type and purpose, all are managed under the auspices of the DOD 5000 series of

directives and contracted for under the Defense Acquisition Regulation. These regulations provide a common operating philosophy for the entire research universe: the set of all FSED SOW experts within the Department of Defense.

Research Population.

The research population consisted of all FSED SOW experts assigned to the Air Force Systems Command, Aeronautical Systems Division at Wright-Patterson Air Force Base, Ohio. In selecting this population, the researchers considered the similarity of FSED program management and contracting in DOD and the time and other resource constraints of the research project. The resources available were more productively expended by focusing on a localized population than topically surveying a large population at large geographic distances. Because all DOD systems acquisitions must conform to standard techniques of systems management and contracting, the research performed on the selected population can be generalized to the research universe.

Sampling Plan

While purposive sampling is often used for experience surveys, the researchers conducted a random sampling to strengthen statistical testing of the Research Hypothesis.

The Directorate of Contracting, under the ASD Deputy for Contracting and Manufacturing (ASD/PMW) maintains computerized records of ASD civilian contracts personnel. The records contain the grade and job type for each individual by name, along with current organizational assignment. Similar data is maintained for military contracts personnel in manual form. From these records a list was generated of all ASD personnel, military and civilian, of grade O-2/GS-11 or above, employed in contracting, contract review, contract policy, or contract management. This action produced a list of 315 personnel, an indefinite subset of which was the research population.

The researchers sampled names from the list and, after initial contact to confirm the remaining criteria, selected only those that met the remaining criteria. This sampling was performed first, by numbering each name on the list in order, 1-315.

From the table of random numbers (Appendix A) a seed number was randomly drawn. Beginning with the seed number, the first three digits of each five digit

grouping was drawn. Three digit groupings of 000 and 316 or larger were discarded. Groupings between 001 and 315, inclusive, were recorded on the first time drawn. Names corresponding to the numbers drawn were listed in the order of draw.

The randomly drawn names were discussed with ASD/PMW managers to ascertain the time each listed person had spent in systems acquisition. Those having less than thirty months experience were removed from consideration.

The remaining persons listed were contacted and surveyed as to number of assignments held and number of FSED SOWs or contracts worked with. Those having held more than one assignment and having worked with two or more SOWs or contracts were asked to take part in the survey.

This sampling method resulted in a random sampling of elements from the research population.

C. Selltiz and others point out that, typically in experience surveys, as more experts are surveyed, fewer new insights are obtained (24:56). Rather than arbitrarily limit the number of experts surveyed, the principle of decreasing returns was employed in the sample.

The initial process of obtaining responses for the Research Question determined the size of the sample; SOW experts were surveyed for responses until the point that no new responses were received. No new data (of any substance) was obtained at the point that an expert interview produced only responses that had been previously obtained.

Research Question

Data Collection Plan. The purpose of the Research Question was to explore and identify factors that contribute to successful communication in FSED SOWs. An experience survey is to gather and synthesize such experience (24:55). The experience survey of ASD FSED SOW experts utilized personal interviews. A focused interview was used, of the type described by Merton, Fiske, and Kendall:

In the focused interview. . . the main function of the interviewer is to focus attention upon a given experience and its effects. He knows in advance what topics, or what aspects of a question, he wishes to cover. Although the respondent is free to express completely his own line of thought, the direction of the interview is clearly in the hands of the interviewer. He wants definite types of information, and part of his task is to confine the respondent to discussion of the issues about which he wants knowledge [24:264].

The interview guide in Appendix B was developed and implemented for the focused interview. The validity of the guide was established through trial interviews of School of Systems and Logistics students. Trial

respondents were selected on the basis of having met the criteria for expertise previously described. Respondent comments concerning the format of the interview were noted and changes were made where necessary.

Design to Answer the Research Question. The specific factors obtained from the interviews were tabulated into a single list. Identical responses were recorded only once. Responses that differed verbally, but were the same conceptually were considered to be the same response. This precluded redundancy of factors in the final list. The final list constituted the answer to the Research Question.

Research Hypothesis

Data Collection Plan. The Statement of Work experts interviewed for the Research Question were contacted again to provide data for the Research Hypothesis. A list of factors coded from the Research Question response list was given to each expert. Each was then instructed to rank the factors in order of importance to successful FSED Statement of Work communication with Number 1 being the most important, Number 2 the second most, and so on.

Design to Test Research Hypothesis. The rank ordered factors obtained constituted ordinal level data. Ordinal level data is data which is characterized by some order. The elements of the data are transitively related, that is, of greater or lesser value to each other. There is no standard of value implied to ordinal data. Elements are known to be greater or lesser than each other, but without degree. Ordinal data also implies no origin, i.e., no zero value (6:113).

The lack of magnitude measure in the ordinal level data prevented the effective use of parametric statistical tests. The researchers selected a non-parametric statistical technique, applicable to ordinal data, for the testing. Specifically, this was Kendall's Coefficient of Concordance (w) (24:229-238). The Coefficient of Concordance is a measure of the degree of agreement between k raters (experts) ranking N items. A summary of the mechanics of the Kendall w is found in Appendix C.

The null hypothesis (H_0) was that there was no significant agreement between experts as to the order of importance of the factors to successful SOW communication. The alternate hypothesis (H_1) was that there was a significant agreement between experts.

The decision rule for the test depended upon the critical Kendall W value and the number of factors rated (N). The significance of .05 was assumed for the hypothesis test.

Two decision rule formats were possible, depending on the size of N . For N less than or equal to 7, the decision rule would have been based on critical values of W :

If $W < W_{critical}$, conclude H_0

If $W \geq W_{critical}$, reject H_0 , assume H_1

If the critical value of W (Appendix C) was greater than the W determined from the sample, there would have been no statistical basis to believe that the agreement between experts was anything more than random, i.e., there would have been no agreement. If W was greater than or equal to the critical W value, however, there would have been sufficient statistical evidence to indicate that some process or pattern of agreement was present. Thus the null hypothesis would have been rejected and the alternate hypothesis accepted.

For N greater than 7, the decision rule would have been based upon a comparison of a weighted W approximation of the χ^2 distribution with the actual χ^2 distribution at $(N-1)$ degrees of freedom:

If significance of $\chi^2 = k(N-1)W$ was greater than .05, conclude H_0

If significance of $\chi^2 = k(N-1)W$ was less than or equal to .05, reject H_0 , assume H_1

If the critical χ^2 value at $(N-1)$ degrees of freedom was associated with a significance value greater than .05 (i.e., of lower confidence) there would have been no basis for assuming any agreement other than random. A value less than or equal to .05 would have indicated rejection of the assumption of no agreement.

Limitations and Assumptions

Existing limitations and necessary assumptions, as specified below, affected the research design:

Limitation No. 1. No definitive list of ASD SOW experts existed.

Limitation No. 2. Researcher interpretation of Research Question responses was necessary to avoid redundancy.

Assumption No. 1. Contracting methods and SOW communication among DOD contracts are similar.

Assumption No. 2. Experts were most likely found in contracting, contract review, management, and policy organizations.

CHAPTER IV

DATA COLLECTION AND ANALYSIS

This chapter provides the results of the data collection described in the Research Methodology chapter. Also provided are analyses of the Research Question and Research Hypothesis.

Sample Results

The number of interviews performed for Research Question data collection depended upon the receipt of new responses. When interviews ceased to yield new responses, interviewing was terminated.

A list of factors was generated from the focused interviews. As each new interview was completed, the factors resulting from that interview were compared with those already on the list. Those new factors that were not duplicates of those already on the list were added to the list.

As more interviews were conducted, fewer new factors appeared. The fifteenth interview produced no new factors. Interviewing for the Research Question was then terminated.

Research Question Results

The fifteenth interview with FSED SOW experts resulted in a list of twenty-five distinct factors that bear upon the success of SOW communication. This list, together with similar descriptors and explanatory observations gleaned during the interviews, where applicable, follows. The order of the listing does not reflect importance or frequency of occurrence for the response.

1. Clear, unambiguous definition of requirements.

Requirements were viewed as tasks performed by the contractor. Interviewees were concerned that requirements should be complete and specifically stated in mutually understood, measurable criteria.

2. Sincere, realistic requirements. Requirements should be technically feasible. Some respondents observed that requirements are at times written in expectation that the contractor will not reach the specified performance level, i.e., with the intent to "challenge" the contractor. It was perceived that contractors are aware of the lack of realism expressed in such requirements and take them no more seriously than those levying the requirements.

3. Critical requirements distinguished from non-critical requirements. Respondents were concerned that the priority of requirements should be specifically stated. "Nice-to-have" tasks should be distinguished from "must-have" tasks.

4. Variable (trade-off) requirements distinguished from absolute requirements. Absolute requirements should be stated in firm quantitative terms. Requirements that may be subjected to trade-offs between each other should be so identified with acceptable quantitative ranges.

5. Graphics/visual descriptions used when appropriate. Some requirements can often be more clearly expressed through the use of schedules, diagrams, or drawings.

6. Incorporated documents tailored to requirements. Requirements expressed in documents such as military standards or specifications should be modified to fit the particular SOW in which they are incorporated. Several respondents commented that standards and specifications are often incorporated without review and that many requirements levied upon the contractor are vague, unnecessary, or meaningless.

7. Terminology consistent. The same term or description that refers to a task or concept should be used throughout the SOW. Clarity should have precedence over variety.

8. SOW statements non-contradictory. Statements in the SOW should be compatible with each other; requirements should not conflict.

9. Easy to read/use paragraph numbering system. Some paragraph numbering systems can confuse through similarity and number of characters and that such systems should be avoided.

10. Consistent format and organization in SOW document. The SOW format should be the same throughout.

11. SOW logically organized. The SOW should be organized so that requirements are presented in a predictable, non-disjointed manner.

12. SOW paragraphs reference Contract Data Requirements List (CDRL). SOW paragraphs often prescribe tasks that directly or indirectly generate data items. Several respondents considered it beneficial to reference the paragraph to the contractual data requirement in the CDRL.

13. SOW paragraphs reference other contract documents. Similar to CDRL references, some respondents believed it beneficial for the pertinent SOW requirement to reference other contract documents by section or paragraph where such information will bear on understanding or performance of that SOW requirement.

14. Terms and acronyms defined. SOW writers should not assume that everyone reading the SOW understands the terms and acronyms used nor that they understand terms and acronyms consistently.

15. Concise Language. Requirements should be expressed in as few words as possible.

16. Clear, precise language. Language and style should be readily understood. Modifiers should be used to define requirements as opposed to expanding them. Descriptors should be in measurable criteria; superlatives should be avoided.

17. Draft SOW reviewed and commented on by contractor. Respondents favored contractor review and comment on the draft SOW and other draft RFP documents.

18. Government-contractor exchange meetings held concerning the draft SOW. Respondents favored meetings between Government and contractor management and functional discipline counterparts.

19. Development/writing of SOW accomplished by integrated Government effort. The SOW should be developed and written by an integrated, coordinated team of Government functional representatives.

20. Leadership of SOW writing effort. Most respondents identified the program or project manager as the individual who should exert leadership in the SOW development and writing efforts. Additional suggestions for the leadership role were the buyer/contracting officer and the chief engineer or systems engineer.

21. Individual functional office comprehension of program objectives and requirements. Government functional specialists should be made aware of the primary program goals and requirements/SOW tasks.

22. SOW reviewed by Government contracts office. The SOW should be reviewed by the contracting office.

23. Internal Government review of SOW. The Government should review the SOW prior to placing it on contract if the SOW was contractor-developed.

24. User agency participation in SOW development/writing. Agencies that will use the system should participate in the development and writing of the SOW.

25. Program manager guidance to the team.

The program manager should provide program background and acquisition strategy to the Acquisition Team Members.

Research Hypothesis Data Collection

The twenty-five Research Question responses exhibited some obvious similar themes and concerns. To emphasize major subjects during hypothesis testing, the researchers elected to code the twenty-five responses into categories.

Coding for Hypothesis Testing. The coding process did not lend itself to extensive pre-planning. The researchers resorted to inductive coding, a technique described by D. and C. Nachmias:

In exploratory research or in pilot studies, data are collected without a predesigned system of categories. Therefore, the coding scheme is constructed on the basis of raw material.

The inductive method is most frequently applied to coding responses to open-ended questions or to data obtained from documents or through the method of participant observation.

With the inductive method of coding, the first step is to select a representative sample of responses . . . When the selection is sufficiently large and varied for a pattern to emerge, the coding scheme can be constructed. This preliminary scheme is then systematically applied to the data.

Categories are not always easily identified. Often, the process of constructing a coding scheme is a long one and involves switching back and forth between the raw data and the evolving scheme until the latter is applicable and ties in with the general purpose of the study [18:145-146].

In accordance with the inductive technique, the twenty-five responses were first searched for salient common subjects to be used as coding categories. Seven emerged:

1. Requirements
2. Consistency
3. Internal Document Organization
4. Contract Cross-referencing
5. Language
6. Contractor Participation
7. Government Personnel Team Effort

Following establishment of this coding scheme, each of the twenty-five responses was assigned to the most appropriate of the seven categories. The results of the coding are shown in Appendix E and reflect the coding judgment of the researchers. This is in concert with typical conditions for inductive coding as described by Nachmias':

In coding open-ended questions or non-structured material, coders are required to exercise their own judgment in classifying responses according to the coding scheme [18:150].

Test Instrument. A statement was written about each of the seven categories. These statements were then arranged in a random order to preclude bias of presentation in the Research Hypothesis test instrument. The test instrument, "FSED Statement of Work Priority Survey," is shown in Appendix F.

The instrument was validated through trial surveys of Graduate Logistics Program students at the School of Systems and Logistics. Comments were noted and changes to the survey format were made where necessary.

Research Hypothesis Results

The responses from the Research Hypothesis were arranged in matrix format and are displayed in Appendix G.

Appendix G also shows the sums of the ranks R_j for each of the columns of ranks.

The Kendall Coefficient of Concordance (W) was used to test the Research Hypothesis that there is agreement between the experts. The formal hypothesis test structure was as follows:

- H_0 : There is no significant agreement between experts as to the importance of the factors upon successful SOW communication.
- H_1 : There is significant agreement between experts.

The format for the decision rule employed was dependent upon the number of factors N ranked by the fifteen experts. The $N=7$ factors ranked indicated the use of the following decision rule:

If $W < W_{\text{critical}}$, conclude H_0

If $W \geq W_{\text{critical}}$, reject H_0 , accept H_1

The w_{critical} value depended upon the critical sum of squares value s for $k=15$, $N=7$ (25:286) shown in Appendix D.

The critical s value is:

$$s = 864.9$$

$$\begin{aligned} W_{\text{critical}} &= \frac{s_{\text{critical}}}{1/12k^2(N^3-N)} \\ &= \frac{864.9}{6300} \end{aligned}$$

$$W_{\text{critical}} = .1373$$

The critical w of .1373 is the point of statistical significance for $k=15$ and $N=7$ at .05 significance. Below this value, w indicates that there is no significant deviation from 0, i.e., the rankings are independent. For w equal to or greater than this value, there is significant deviation from 0, i.e., rankings are not independent and some underlying agreement process is active. The decision rules were thus established:

If $W < .1373$, conclude H_0

If $W \geq .1373$, reject H_0 , accept H_1

The R_j having been derived from the basic data in Appendix G, the mean of all R_j was determined:

$$\begin{aligned}\Sigma R_j / N &= (81 + 53 + 43 + 44 + 61 + 51 + 87) / 7 \\ &= 420 / 7\end{aligned}$$

$$\Sigma R_j / N = 60$$

Next, the mean was subtracted from each R_j :

$$(81-60) = 21$$

$$(53-60) = -7$$

$$(43-60) = -17$$

$$(44-60) = -16$$

$$(61-60) = 1$$

$$(51-60) = -9$$

$$(87-60) = 27$$

Each deviation was then squared:

$$(21)^2 = 441$$

$$(-7)^2 = 49$$

$$(-17)^2 = 289$$

$$(-16)^2 = 256$$

$$(1)^2 = 1$$

$$(-9)^2 = 81$$

$$(27)^2 = 721$$

The squares were then summed to obtain s :

$$\begin{aligned}s &= (441 + 49 + 289 + 256 + 1 + 81 + 721) \\ &= 1846\end{aligned}$$

W was then computed using the denominator previously derived:

$$W = \frac{s}{1/12k^2(N^3 - N)}$$

$$W = \frac{1846}{6300}$$

$$W = .2930$$

Given:

If $W < .1373$, conclude H_0

If $W \geq .1373$, reject H_0 , accept H_1

$$W = .2930 \geq .1373$$

As a result of W being greater than $W_{critical}$, it was concluded to reject the null hypothesis that there is no agreement and to accept the alternate that there is agreement.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The research described in the previous chapters was performed with two objectives: to identify factors that contribute to successful communication in FSED Statements of Work and to determine if there was any agreement of factor order. Some conclusions concerning the contributions of the research toward these objectives are provided in this chapter. Also provided are some recommendations for the further development and application of the research results.

Research Question Conclusions

The ASD experts, individually, provided twenty-five factors that contribute to successful communication in FSED SOWs. These twenty-five responses are representative but not exhaustive, constrained in number by the research design. There are certainly others that are important to successful SOW communication.

The twenty-five factors focus attention on seven primary subjects: the requirements described by the SOW, the consistency of the SOW, the internal organization of the SOW document, cross-referencing of the SOW to other contract

documents, SOW language clarity, the participation of the contractor in SOW preparation, and the effort of the Government team tasked with the development and writing of the SOW. These are major areas of concern that must be accounted for in the writing of FSED SOWs if the SOWs are to communicate successfully. They must be considered by all functional representatives engaged in FSED SOW development and writing.

All DOD system FSED programs have characteristics common to those of ASD. All are managed under the DOD 5000 series of directives and contracted for in accordance with the Defense Acquisition Regulation. Because all FSED SOWs must meet these general imperatives, the seven major areas of concern should be considered in acquisition organizations DOD-wide.

Research Hypothesis Conclusions

The Research Hypothesis that there is agreement as to the importance of the factors identified was supported. The Kendall Coefficient of Concordance test demonstrated that agreement between the SOW experts was significantly greater than random.

The presence of agreement between the experts supports a position that some of the seven major areas of concern have greater impacts on successful SOW communication than others.

Corollary Conclusions

The order of importance to successful SOW communication of the seven major areas of concern is pointed to by the rankings received in the Research Hypothesis data collection (Appendix G).

With exceptions, the area of contractor participation in SOW preparation received the lowest numerical ratings, showing general agreement that this is the least important factor contributing to successful SOW communication. SOW cross-referencing received the next lowest marks.

Clarity of language and requirements description received the highest rankings, indicating their perceived importance to successful SOW communication.

While these rankings suggest relative importance between the areas of concern, the ordinal nature of the data gives no suggestion of how much more important one area is than another. While the areas probably should be emphasized differently in SOW preparation, this does not mean that some should be considered and others not.

Recommendations

Field Implementation. A knowledge of the major areas of concern to successful FSED SOW communication would be beneficial to all personnel engaged in SOW preparation. It is recommended that the seven major areas of concern be given

as wide a dissemination as possible. This would include publication as an open letter, professional journal submission, addendum to current SOW writing instructions, and discussion in acquisition seminars.

For SOW communication to increase in success, personnel who engage in SOW preparation must not only be aware of the areas of concern, they must implement them as criteria against which SOWs are written. It is recommended that program managers and supervisors promote the consideration of these areas during SOW preparation and establish controls to insure that the areas are considered during SOW preparation.

It is further recommended that all areas of concern be emphasized. While there is an implication that some areas are more important than others, the extent of the difference in importance is not known. It is known, however, that all seven areas, in some measure, contribute to successful communication in FSED SOWs.

Recommendations for Future Research. While this research was undertaken to provide practical information for use in developing and writing FSED SOWs, it was also undertaken as a starting point for future, more statistically definitive SOW research. Replications of this research at other acquisition organizations are recommended.

Replication would provide validation of the techniques employed in this research as well as additional insight into factors affecting successful SOW communication.

Future research is recommended to establish the relative importance of SOW communication factors. Such research could demonstrate which factors should be emphasized most during SOW development and writing. A related research area would be the effects of individual factors upon each other; i.e., correlation between factors. Knowledge of factor inter-effects would provide greater predictability of overall communication success when individual factors are emphasized.

Also recommended is research into ways to quantify and validly measure individual factors and overall communication success. This would provide techniques needed to quantitatively evaluate individual SOWs for communication effectiveness.

Finally, research should be performed to determine the applicability of FSED SOW communication factors to SOW development and writing in other phases of system acquisition. Such research may result in broader applications for the factors identified in this research, or in new factors.

Concluding Comments

It is not expected that the results of this research will provide distinct solutions to the problem of SOW communication. It is hoped, however, to provide system acquisition personnel with an impetus to consider critically the FSED SOWs that they currently write and use, and to recognize the liability of SOWs that fail to communicate successfully. It is also hoped that this research will provide a point of departure for expanded research in a topic area of very little formal knowledge. As long as Statements of Work fail to successfully communicate Government requirements, problems will arise with accompanying loss of resources and opportunity.

APPENDIX A

TABLE OF RANDOM DIGITS

Line	(1)-(5)	(6)-(10)	(11)-(15)	(16)-(20)	(21)-(25)	(26)-(30)	(31)-(35)
101	13284	16834	74151	92027	24670	36665	00770
102	21224	00370	30420	03883	94648	89428	41583
103	99052	47887	81085	64933	66279	80432	65793
104	00199	50993	98603	38452	87890	94624	69721
105	60578	06483	28733	37867	07936	98710	98539
106	91240	18312	17441	01929	18163	69201	31211
107	97458	14229	12063	59611	32249	90466	33216
108	35249	38646	34475	72417	60514	69257	12489
109	38980	46600	11759	11900	46743	27860	77940
110	10750	52745	38749	87365	58959	53731	89295
111	36247	27850	73958	20673	37800	63835	71051
112	70994	66986	99744	72438	01174	42159	11392
113	99638	94702	11463	18148	81386	80431	90628
114	72055	15774	43857	99805	10419	76939	25993
115	24038	65541	85788	55835	38835	59399	13790
116	74976	14631	35908	28221	39470	91548	12854
117	35553	71628	70189	26436	63407	91178	90348
118	35676	12797	51434	82976	42010	26344	92920
119	74815	67523	72985	23183	02446	63594	98924
120	45246	88048	65173	50989	91060	89894	36036
121	76509	47069	86378	41797	11910	49672	88575
122	19689	90332	04315	21358	97248	11188	39062
123	42751	35318	97513	61537	54955	08159	00337
124	11946	22681	45045	13964	57517	59419	58045
125	96518	48688	20996	11090	48396	57177	83867
126	35726	58643	76869	84622	39098	36083	72505
127	39737	42750	48968	70536	84864	64952	38404
128	97025	66492	56177	04049	80312	48028	26408
129	62814	08075	09788	56350	76787	51591	54509
130	25578	22950	15227	83291	41737	59599	96191
131	68763	69576	88991	49662	46704	63362	56625
132	17900	00813	64361	60725	88974	61005	99709
133	71944	60227	63551	71109	05624	43836	58254
134	54684	93691	85132	64399	29182	44324	14491
135	25946	27623	11258	65204	52832	50880	22273
136	01353	39318	44961	44972	91766	90262	56073
137	99083	88191	27662	99113	57174	35571	99884
138	52021	45406	37945	75234	24327	86978	22644
139	78755	47744	43776	83098	03225	14281	83637
140	25282	69106	59180	16257	22810	43609	12224
141	11959	94202	02743	86847	79725	51811	12998
142	11644	13792	98190	01424	30078	28197	55583
143	06307	97912	68110	59812	95448	43244	31262
144	76285	75714	89585	99296	52640	46518	55436
145	55322	07598	39600	60866	63007	20007	66819
146	78017	90928	90220	92503	83375	26986	74399
147	44768	43342	20696	26331	43140	69744	82928
148	25100	19336	14605	86603	51680	97678	24261
149	83612	46623	62876	85197	07824	91392	58317
150	41347	81666	82961	60413	71020	83658	02415

SOURCE: Excerpt from *Table of 105,000 Random Decimal Digits*. Interstate Commerce Commission, Bureau of Transport Economics and Statistics, May 1949.

APPENDIX B

RESEARCH QUESTION INTERVIEW GUIDE

I. Respondent preparation

- A. Assure respondent of confidentiality.
- B. Review research purpose and benefits.
 - 1. Much empirical knowledge of FSED SOW communication exists but very little researched knowledge exists.
 - 2. Research will provide opportunities for improved future SOW writing.
- C. Define research terms.
 - 1. Successful SOW communication.
 - 2. Unsuccessful SOW communication.
- D. Establish response parameters.
 - 1. Focus on FSED SOWs.
 - 2. Focus on SOW attributes which positively contribute to successful SOW communication.
 - 3. Focus on attributes that could affect FSED SOWs in general.
- E. Clarify respondent misunderstanding/answer respondent questions.

II. Respondent query.

- A. Ask central question: "What factors, characteristics and qualities contribute to successful FSED SOW communication?"

B. Assist respondent when necessary.

1. Probe respondent FSED experience if responses focus on attributes that:

(a) Inhibit successful SOW communication.

(b) Contribute to unsuccessful SOW communication.

(c) Inhibit unsuccessful SOW communication.

C. Record correctly formatted responses.

D. Assure respondent agreement with final written response.

III. Respondent post-query.

A. Reassure respondent of confidentiality.

B. Thank respondent.

APPENDIX C

KENDALL COEFFICIENT OF CONCORDANCE W METHOD
(For Significance Tests at .05)

1. Let N equal the number of entities to be ranked and let k equal the number of raters assigning ranks. Arrange observed ranks in a $k \times N$ matrix.
2. For each entity, determine R_j , the sum of the ranks assigned to that entity by the k raters.
3. Determine the mean of all R_j : $(\sum R_j / N)$.
4. Subtract the mean from each R_j .
5. Square the resultant deviations from the mean.
6. Sum the squared deviations to obtain s .
7. Determine W using the following formula:

$$W = \frac{s}{1/12 k^2 (N^3 - N)}$$

8. Test the observed W :
 - a. If $N \leq 7$, refer to the table (25:286) for the critical sum of squares s value for the appropriate k and N combination at .05 significance. Compute the critical W value and test: If $W \geq W_{critical}$, there is a significant agreement. If $W < W_{critical}$, no significant agreement can be identified.

b. If $N > 7$, compute the following χ^2 approximation:

$$\chi^2 = k(N-1)W$$

Refer to the table of significant values for χ^2 (25:249).

If the computed χ^2 is found to be associated with a significance (α) of .05 or less, there is significant agreement; if greater than .05, no significant agreement. (25:229-238)

APPENDIX D

TABLE OF CRITICAL VALUES OF s IN THE KENDALL COEFFICIENT
OF CONCORDANCE*

k	N					Additional values for $N = 3$	
	3†	4	5	6	7	k	s
Values at the .05 level of significance							
3			64.4	103.9	157.3	9	54.0
4		49.5	88.4	143.3	217.0	12	71.9
5		62.6	112.3	182.4	276.2	14	83.8
6		75.7	136.1	221.4	335.2	16	95.8
8	48.1	101.7	183.7	299.0	453.1	18	107.7
10	60.0	127.8	231.2	376.7	571.0		
15	89.8	192.9	349.8	570.5	864.9		
20	119.7	258.0	468.5	764.4	1,153.7		
Values at the .01 level of significance							
3			75.6	122.8	185.6	9	75.9
4		61.4	109.3	176.2	265.0	12	103.5
5		80.5	142.8	229.4	343.8	14	121.9
6		99.5	176.1	282.4	422.6	16	140.2
8	66.8	137.4	242.7	388.3	579.9	18	158.6
10	85.1	175.3	309.1	494.0	737.0		
15	131.0	269.8	475.2	758.2	1,129.5		
20	177.0	364.2	641.2	1,022.2	1,521.9		

* Adapted from Friedman, M. 1940. A comparison of alternative tests of significance for the problem of m rankings. *Ann. Math. Statist.*, 11, 86-92, with the kind permission of the author and the publisher.

† Notice that additional critical values of s for $N = 3$ are given in the right-hand column of this table.

[25:286]

APPENDIX E

RESEARCH HYPOTHESIS CODING RESULTS

Requirements

1. Clear, unambiguous definition of requirements.
2. Sincere, realistic requirements.
3. Critical requirements distinguished from non-critical requirements.
4. Variable (trade-off) requirements distinguished from absolute requirements.
6. Incorporated documents tailored to requirements.
21. Individual functional office comprehension of program objectives and requirements.

Consistency

7. Written terminology consistent.
8. SOW statements non-contradictory.

Internal Document Organization

9. Easy to read/use paragraph numbering system.
10. Consistent format and organization in SOW document.
11. SOW logically organized.

Contract Cross-Referencing

12. SOW paragraphs reference Contract Data Requirements List (CDRL)
13. SOW paragraphs reference other contract documents.

Language

- 5. Graphics/visual descriptions used when appropriate.
- 14. Terms and acronyms defined.
- 15. Concise language.
- 16. Clear, precise language.

Contractor Participation

- 17. Draft SOW reviewed and commented on by Contractor.
- 18. Government-Contractor interchange meetings held concerning draft SOW.

Government Personnel Team Effort

- 19. Development/writing of SOW accomplished by integrated Government effort.
- 20. Leadership of SOW writing effort.
- 22. SOW reviewed by Government contracts office.
- 23. Internal Government review of SOW.
- 24. User agency participation in SOW development/writing.
- 25. Program manager guidance to the Acquisition team.

APPENDIX F

FSED STATEMENT OF WORK PRIORITY SURVEY

A few weeks ago, you and several other people were interviewed and asked for your opinions of factors, characteristics, and qualities that contribute to successful FSED Statement of Work communication*. These interviews provided a number of general SOW communication factors.

Below are seven statements about different SOW communication factors. Please read them and rank them in the order that you feel they are important to successful SOW communication. Rank them 1 through 7, with 1 as the most important, in the spaces provided at the right of each statement. (They have been randomly arranged on the page; their order of appearance has no bearing on their importance.) Please read all seven before ranking them.

1. Individual SOW paragraphs are referenced with related requirements in other documents. _____
2. The organization of the SOW document is logical and consistent. _____
3. The SOW is written in clear language. _____
4. The SOW requirements are realistic and unambiguous with allowable requirement variations clearly defined. _____
5. The writing and review of the SOW is accomplished under program office management by representatives of functional disciplines and program-related agencies. _____
6. The terms and statements in the SOW are consistent and compatible. _____
7. The Contractor is afforded the opportunity to review and comment on the draft SOW. _____

* SUCCESSFUL SOW COMMUNICATION is an event that occurs when the Government requirements transmitted by the SOW are received and interpreted by the Contractor as the Government intended, and Government-contractor understanding and agreement are established.

APPENDIX G

RESEARCH HYPOTHESIS SURVEY RESULTS

	ITEM (N)						
	1	2	3	4	5	6	7
1	7	5	4	1	2	3	6
2	3	1	2	4	5	7	6
3	5	4	3	1	6	2	7
4	5	1	3	2	7	4	6
5	3	6	7	4	1	5	2
6	7	6	2	1	3	5	4
7	5	1	3	4	6	2	7
8	7	4	1	2	5	3	6
9	7	1	3	4	5	2	6
10	4	6	2	5	1	3	7
11	7	5	6	4	1	3	2
12	3	4	1	6	5	2	7
13	6	1	3	2	4	5	7
14	6	4	2	1	5	3	7
15	6	4	1	3	5	2	7
R _j	81	53	43	44	61	51	87

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